Remarks

The Drawings filed on July 21, 2003 are objected to by the Examiner. Figure 1 of the Drawings is amended. A replacement sheet showing the amendment to Figure 1 and a request for drawing amendment are included with this response. The Specification is amended to include missing reference characters in the description.

Claims 1-20 are pending in the application. Claims 1-20 are rejected. All rejections are respectfully traversed.

The invention provides a virtual reality environment by acquiring concurrently, with a plurality of cameras, a plurality of sequences of input images of a 3D object, each camera having a different pose. The plurality of sequences of images is reduced to a differential stream of 3D operators and associated operands. A 3D model of point samples representing the 3D object from the differential stream is maintained. Each point sample of the 3D model has 3D coordinates and intensity information. Then the 3D model is rendered as a sequence of output images of the 3D object from an arbitrary point of view while acquiring and reducing the plurality of sequences of images and maintaining the 3D model in real-time.

Before the rejection is traversed in detail, Applicants would like the Examiner to take note that in computer graphics two types of model representations are commonly used. One model uses a **polygons**, usually triangles, and those models can be called a triangle meshes. The triangles or

polygons are two-dimensional surfaces. The other model is a **point model,** which uses 3D discrete points in space. The number of references that distinguish these models are too numerous to cite, but any standard reference on computer graphics will suffice. The Applicants respectfully request the Examiner to understand and respect this difference, as reflected in the Manual of Classification. Those of ordinary skill in the art would never confuse **point models** as claimed and **triangle models** as cited by the Examiner.

The primary references cited by the Examiner only describe triangle models. Applicants assert vigorously now, and will continue to do so in the future, that the applied art is irrelevant and unrelated to what is claimed. Applicants further request that in the future, if the Examiner is going to consider art, it will be art related to point sample models, and not triangle models.

Claims 1-4, 7, 8, 10 and 13-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. ("Polyhedral Visual Hulls for Real-Time Rendering" - Matusik) in view of Deering (U.S. Patent No. 5,867,167).

The Examiner states that Matusik reduces sequences of images to a differential stream:

> System, 1st paragraph); reducing the plurality of sequences of images to a differential stream (page 123, Section 4 Real-Time System, 1st paragraph); rendering the 3D model

With all due respect, reducing is not described by Matusik. Instead, Matusik describes background subtraction, a stream of silhouettes and texture information:

the video stream at 15 fps and performs the following processing steps: First, it segments out the foreground object using background subtraction. Then, the silhouette and texture information are compressed and sent over a 100Mb/s network to a central server. The system typically processes video at 320×240 resolution. It can optionally

Silhouette and texture are both data. Silhouettes represent *shape*, or '*geometry*' as it typically referred to in computer graphics. Texture maps represent indirectly surface *intensities*. There are no operands in Matusik's stream.

Matusik does not describe a 3D model of *point samples* from the differential stream. In contrast, Matusik's model only represents the silhouette (shape) data:

We assume that each silhouette s is specified by a set of convex or non-convex 2D polygons. These polygons can have holes. Each polygon consists of a set of edges

In constructing his model, Matusik does not consider differential 3D operators and operands, and certainly not intensities.

Matusik does not render a 3D point model.

Moreover, Matusik teaches away from the invention, see title "Polyhedral Visual Hulls ..." The Matusik model is constructed of 2D *polygons*, (also known as triangle meshes, or polyhedral hulls, see title), not 3D discrete *points*. Matusik makes it quite clear that for his model it is an advantage to reduce to the silhouettes to 2D data structures in section 2.2:

2.2 Reduction to 2D

The intersection of a face of a cone with other cones is a 3D operation (these are polygon-polyhedron intersections). It was observed by [10, 16] that these intersections can be reduced to simpler intersections in 2D. This is because each of the silhouette cones has a fixed scaled cross-section; that is, it is defined by a 2D silhouette. Reduction to 2D also allows for less complex 2D data structures to accelerate the intersections.

In the prior art, 3D point (particle) models and 2D polyhedral (triangle mesh) models are clearly distinguished, e.g., see US 6,396,496, Pfister, "Method for modeling graphical objects represented as surface elements." Also see the most well known standard reference text on computer graphics, J. Foley, et al., "Computer Graphics: Principles and Practice," 2nd ed., Addison-Wesley, 1990.

There is no doubt in the art of computer graphics that point and triangle models are essentially incompatible. In fact, a considerable amount of processing needs to be done to convert one model to the other. Neither Matusik, nor Deering below, which also operates on triangle meshes describe such conversions that could make them applicable to what is claimed here.

Furthermore, the Matusik polygon model or "visual hull" only represents object shape. There is no intensity information in the Matusik visual hull. Intensity-like information is stored in texture maps, not the visual hull.

Deering does not reduce *input images* to a differential stream of operators and operands. Deering delta encodes the geometry of his triangle model, see column 12:

> described. Many techniques are known for minimally representing variable-length bit fields but for the geometry compression according to the present invention, a variation of a conventional Huffman algorithm is used.

and at column 17:

> Opcode within state machine **220** processes the values provided by the Huffman tables **230** and outputs data to the barrel shifter unit **240**. State machine **220** also provides an output to data path controller **260**, which outputs a preferably 12-bit wide signal to a tag decoder unit **294** and also outputs data to the barrel shifter unit **240** and to a normal processor **270**, and a position/color processor **280**.

Note, in Deering, the model is generated in step 200, and the delta encoding of the triangle model in steps 230 and 240 takes place later. Deering does not encode a sequence of images.

Also, there are no operators in Deering.

Furthermore, in Deering, the source generates graphic data, not a sequence of images. Therefore, Deering cannot be combined with Matusik. Again, those of ordinary skill of the art would realize that Deering uses a triangle model, and not a point sample model.

Matusik does not describe transmitting a differential stream from the first node to the second node by a network.

Matusik does not represent a moving object by a 3D point model.

Matusik does not represent a segmented object by a differential stream.

Applicant cannot find insert, delete, and update operators in a differential stream anywhere in Deering. The Examiner generally references columns in Deering. The Applicants respectfully assert that the words “insert”, “update”, and “delete” do not appear in Deering. Clarification as to which terms in Deering are believed to be their equivalents is respectfully requested from the Examiner.

Matusik does not have point samples.

Matusik has a single shape/geometry model for all cameras. Section 3 in Matusik deals with texture rendering. As stated previously, texture and shape are treated separately in Matusik.

Matusik does not have point samples. The rendering in Matusik maps textures to triangle mesh, see Matusik throughout.

Matusik does not have a differential stream.

The normals in Deering are surface normals of triangles, and not normals of point samples, see column 9:

> The compression of surface normals will now be described. Traditionally 96-bit normals (three 32-bit IEEE

Reflectance properties of point samples are not described by Matusik or Deering.

Claims 9, 12, 19 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. ("Polyhedral Visual Hulls for Real-Time Rendering") in view of Deering (U.S. Patent No. 5,867,167) and further in view of Pauly et al. ("Spectral Processing of Point-Sampled Geometry").

As stated previously, point sampled models are incompatible with triangles models. None of the art of Pauley can be combined with either Deering and/or Matusik. Specifically point splatting techniques can **never** be applied to triangles.

Claims 5 and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. ("Polyhedral Visual Hulls for Real-Time Rendering") in view of Deering (U.S. Patent No. 5,867,167) and further in view of Kanade et al. ("Virtualized Reality: Constructing Virtual Worlds from Real Scenes").

Kanade also uses a triangle mesh for his model. None of the art described by Kanade can be used to reject what is claimed.

Claim 6 is rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. ("Polyhedral Visual Hulls for Real-Time Rendering") in view of Deering (U.S. Patent No. 5,867,167) and further in view of Lee et al. (U.S. Patent No. 5,684,887).

Lee deals with recovering background using monocular vision. There are two basic problems with Lee. First, the invention discards the background; therefore, Lee is of no use. Matusik also discards the background; therefore, Lee cannot be combined with Matusik. Furthermore, Lee deals with *monocular* vision. In the claimed invention, the cameras are at different poses, and by definition can not be from the same view. The art of Lee is useless.

It is believed that this application is now in condition for allowance. A notice to this effect is respectfully requested. Should further questions arise concerning this application, the Examiner is invited to call Applicant's agent at the number listed below. Please charge any shortage in fees due in connection with the filing of this paper to Deposit Account 50-0749.

Respectfully submitted,
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